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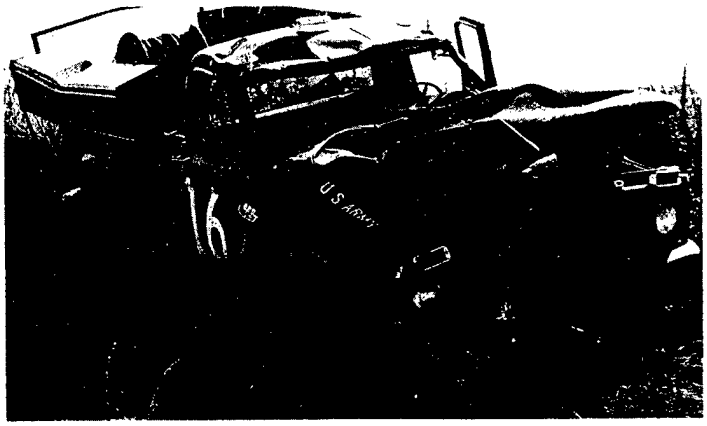

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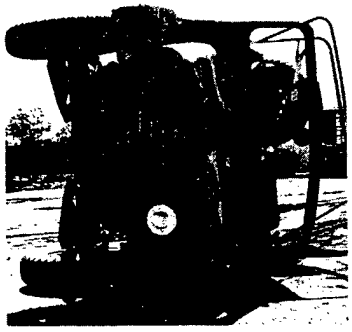
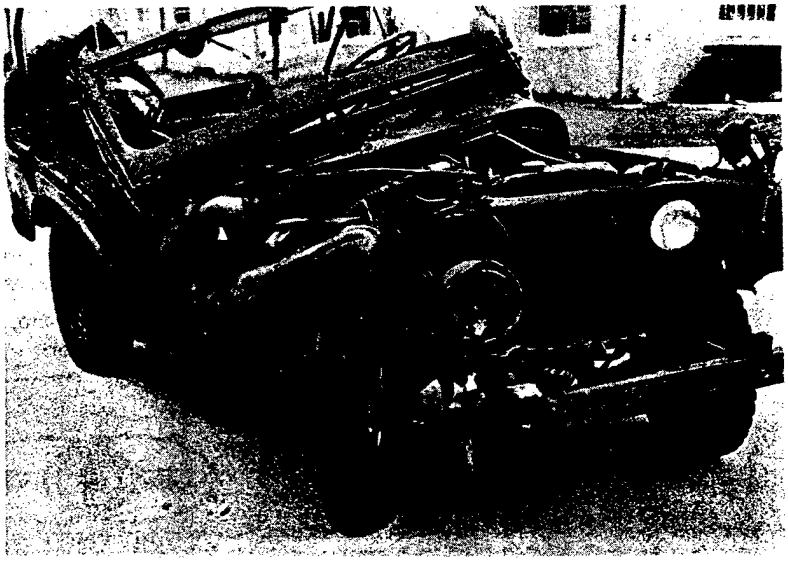
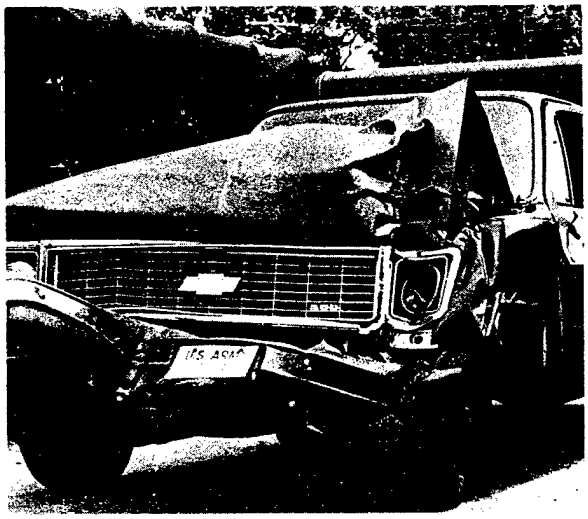
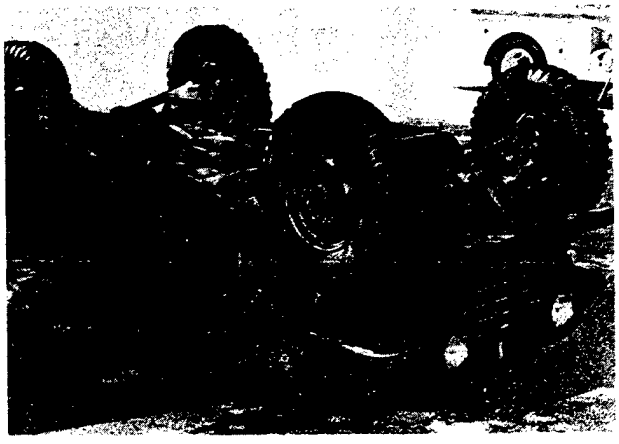






# Analysis of FY 79 Army Motor Vehicle Accidents



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# Analysis of FY 79 Army Motor Vehicle Accidents

prepared by
Darwin S. Ricketson
Mary Ann Thomas

**Directorate for**
**Investigation, Analysis, and Research**
Colonel F.Trevino, Jr.
Director

U.S. ARMY SAFETY CENTER

**Colonel E. E. Waldron II**
**Commander**

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The analysis found Army motor vehicle (AMV) accidents to be the most frequent type of accident reported in fiscal year 79. Driver error was involved in most (71%) of the accidents. The accidents were divided almost equally between commercial/administrative (45%) and tactical (51%) vehicles. However, accidents involving tactical vehicles were much more severe in terms of injuries and cost. Separate analyses of tactical vehicles making the largest contribution to AMV accidents are presented.

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# Summary


The analysis found Army Motor Vehicle (AMV) accidents to be the most frequent type of accident reported in fiscal year 79. The general cause factors were driver error (71%), hazardous surface conditions (36%), unsafe mechanical/physical condition (28%), and adverse weather (19%). (Note that factors total to more than 100 percent because an accident can be caused by more than one factor.)

The accidents were divided almost equally between commercial/administrative and tactical vehicles. However, accidents involving tactical vehicles were much more severe in terms of injuries and cost. Separate analyses of tactical vehicles making the largest contribution to AMV accidents were performed and highlights are presented below.

- **M561/M792 Gamma Goat and M151 Jeep.** These vehicles were real injury producers because they overturned so often. The problem appears to be that they are designed for off-the-road operations but are frequently used on the road where they are expected to drive like commercial vehicles.
- **M880 1¼-ton truck.** Excessive speed and improper backing were significant causes of M880 accidents. Although the average reported speed was only 33 mph, it was excessive for hazardous road conditions such as snow, ice, rain, and turns/curves. Most of the improper backing accidents occurred on administrative/garrison type missions without the aid of a ground guide.
- **2½- and 5-ton trucks.** Brake failure accounted for half of the mechanical defects that caused tactical vehicle accidents. Worse still, brake failure was responsible for 75 percent of the mechanical defects causing 2½- and 5-ton truck accidents. The failed components were brake lines, hydravacs, emergency brakes (while parked), wheel cylinders, and master cylinders.
- **8- and 10-ton trucks.** Improper turning was an important cause of 8- and 10-ton truck accidents. Most of these accidents occurred at intersections with the trailer or towed vehicle hitting a parked or stationary vehicle.

These findings should be helpful to system managers, safety professionals, commanders, and vehicle operators in preventing future AMV accidents.

# Analysis of FY 79 Army Motor Vehicle Accidents

## Introduction

In fiscal year (FY) 79, the U.S. Army had 20,431 accidents reported on DA Form 285. The injury and property cost of these accidents was $78.5 million. Figure 1 shows that Army Motor Vehicle (AMV) accidents were the most frequent type. They accounted for 32 percent of all accidents and 25 percent of all accident costs.

The objective of this analysis was to identify the human error, materiel failure, and environmental factors that cause AMV accidents. It is hoped that this information will assist system managers, safety personnel, commanders, and vehicle operators in their efforts to reduce AMV accidents.

## Method

A two-stage analysis of AMV accidents was performed. First, an analysis of statistical data was performed to determine the types of drivers, collisions, cause factors, and vehicles involved. Significant findings were identified by testing the statistical differences between independent proportions. Second, accident reports of the type vehicles making the largest contribution to the AMV problem were reviewed to reveal specific cause factors. Findings of this two-stage analysis are presented below.

## Findings

### Driver profile

There were 6,947 drivers involved in these AMV accidents. Of these, 93 percent were military personnel and 7 percent were civilians. Where specified, the average military rank was E4 for enlisted, W2 for warrant officers, and 03 for officers. The average civilian grade was GS-6 for General Schedule employees, and WG-8 for Wage Grade employees. The average age of all AMV drivers was 26.

### Type collision

More than 90 percent (5,809) of AMV accidents were accounted for by four types of collisions:

- *Collision between two moving vehicles* (37%). In these collisions, there was a significantly larger proportion of commercial sedans/station wagons (55%) and 1/4- to 3/4-ton commercial trucks (42%) involved than the average AMV (37%).
- *Collision with a parked or standing vehicle* (28%). These collisions involved a significantly larger proportion of buses (42%), 2½-ton tactical trucks (34%), and 5-ton tactical trucks (33%) than the average AMV (28%).
- *Collision with a fixed object (other than a vehicle)* (17%). In these collisions, there was a significantly larger proportion of heavy equipment transporters (32%), M880 series trucks (21%), and emergency vehicles (25%) than the average AMV (17%).
- *Overturned* (9%). In accidents where the vehicle *overturned,* there was a significantly larger proportion of ¼-ton trucks (Jeeps) (25%) and M561/M792 Gamma Goats (18%) than the average AMV (9%).

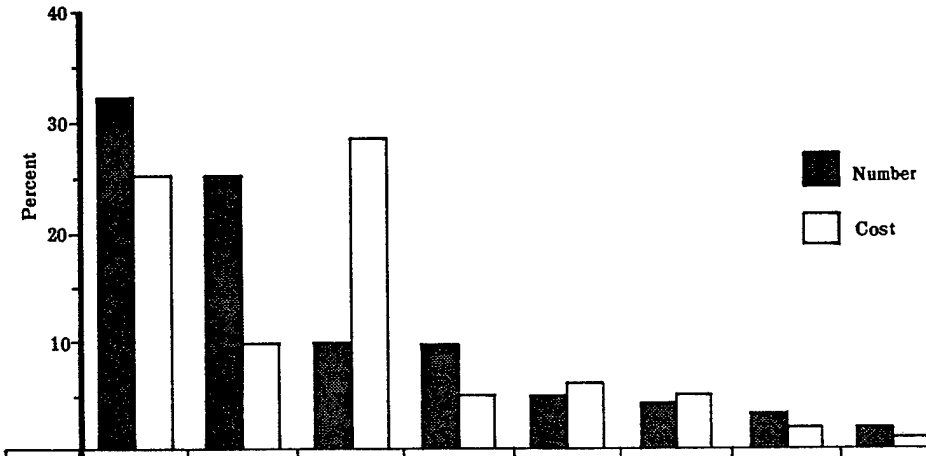
### Cause factors

Four basic types of cause factors contributed to the AMV accidents:

- **Unsafe acts**—Seventy-one percent (4,681) of the accidents involved at least one driver error. In these accidents, the most frequent categories of unsafe acts were:

a. *Using unsafe equipment, hands instead of equipment, or equipment unsafely* (58%). In this category, there was a significantly larger proportion of buses (67%) than the average AMV (58%).

b. *Operating or working at an unsafe speed* (19%). In this category, there




| Type | | AMV | Inj-Job | N-AMV (POV) | Inj-Oth | Inj-Rec | Oth-Nec | Inj-Qtrs | Inj-Maneuver | Track | Parachute | Total Top 10 | Total All Acdts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acdt | n | 6,600 | 5,088 | 2,046 | 1,802 | 1,073 | 745 | 606 | 511 | 380 | 353 | 19,204 | 20,431 |
| | % | 32 | 25 | 10 | 9 | 5 | 4 | 3 | 2 | 2 | 2 | 94 | 100 |
| Cost | $ | 19.9M | 8.2M | 21.7M | 4.2M | 4.5M | 3.7M | 1.4M | 0.7M | 2.1M | 1.3M | 67.7M | 78.5M |
| | % | 25 | 10 | 28 | 5 | 6 | 5 | 2 | 1 | 3 | 2 | 87 | 100 |

FIGURE 1.—Number and Cost of the 10 Most Frequent Types of Accidents in FY 79 (as of 13 March 1980)

was a significantly larger proportion of ¼-ton trucks (Jeeps) (24%), M880 series trucks (22%), and emergency vehicles (24%) than the average AMV (19%).

c. *Taking unsafe position or posture* (12%). In this category, there was a significantly larger proportion of 5-ton tactical trucks (15%), commercial sedans/station wagons (15%), and buses (17%) than the average AMV (12%).

• **Surface condition**—Thirty-six percent (2,364) of the accidents involved at least one hazardous *surface condition.* The most frequent categories of these conditions were:

a. *Wet* (29%). In this category, there was a significantly larger proportion of commercial sedans/station wagons (33%) and commercial/administrative trucks over 1 ton (37%) than the average AMV (29%).

b. *Slippery* (25%). In this category, there was a significantly larger proportion of commercial sedans/station wagons (30%) than the average AMV (25%).

c. *Snow/ice/sleet/frost* (27%). In this category, there was a significantly larger proportion of commercial sedans/station wagons (32%) and M880 series trucks (33%) than the average AMV (27%).

• **Unsafe mechanical/physical condition**—Twenty-eight percent (1,821) of the accidents involved at least one *unsafe mechanical/physical condition.* The most frequent categories of these conditions were:

a. *Mechanical defects* (25%). In this category, there was a significantly larger proportion of 2½-ton tactical trucks (47%), M561/M792 Gamma Goats (42%), and 5-ton tactical trucks (40%) than the average AMV (25%).

b. *Hazardous arrangement/procedure* (17%). In this category, there was a significantly larger proportion of 8- and 10-ton tactical trucks (38%), unspecified tactical trucks (24%), and commercial/administrative trucks over 1 ton (25%) than the average AMV (17%).

c. *Improper illumination* (10%). No type of vehicle was affected by this condition significantly more than the average AMV.

• **Weather**—Nineteen percent (1,244) of the accidents involved *weather* as a cause factor. The most frequent categories of these conditions were:

a. *Rain* (51%). In this category, there was a significantly larger proportion of commercial/administrative trucks over 1 ton (62%) than the average AMV (51%).

b. *Snow* (18%). No type of vehicle was affected by this condition significantly more than the average AMV.

c. *Extreme low temperature* (13%). In this category, there was a significantly larger proportion of 2½-ton tactical trucks (20%) than the average AMV (13%).

d. *Fog* (11%). No type of vehicle was affected by this condition significantly more than the average AMV.

It should be noted that mishap cause factors add to more than 100 percent because an accident may be caused by more than one factor.

**Type vehicle**

Table 1 shows AMV accidents by type vehicle. These accidents were divided almost equally between *commercial/administrative* (45%) and *tactical* (51%) vehicles. However, the *tactical* group accounted for 69 percent of the cost and 68 percent of the injuries. The disproportionate contribution of *tactical* vehicles to the AMV accident problem is further evidenced as follows.

• *Tactical* vehicle accidents were more severe than *commercial/administrative* in terms of:

a. Number of fatalities (59 vs. 7).

b. Number of nonfatal injuries (629 vs. 276).

c. Average injury cost ($1,390 vs. $331).

d. Average property damage ($2,735 vs. $1,463).

e. Average total cost ($4,126 vs. $1,795).

• In terms of the proportion of vehicle accidents producing injuries, the top three were *tactical:*

a. M561/M792 Gamma Goat (40% produced injuries).

b. ¼-ton truck (Jeep) (38% produced injuries).

c. 2½-ton tactical truck (18% produced injuries).

It should be noted that 15 percent of AMV accidents produced injuries.

• Of all AMV accidents, the seven with the highest average accident cost were all *tactical* vehicles:

a. Heavy equipment transporter (HET) ($8,913).

b. M561/M792 Gamma Goat ($6,713).

c. 2½-ton tactical truck ($5,815).

d. 5-ton tactical truck ($4,763).

e. 8- and 10-ton tactical truck ($4,434).

f. ¼-ton truck (Jeep) ($3,630).

g. M880 series truck ($3,195).

It should be noted that the cost of the average AMV accident was $3,019.

• *Tactical* vehicles make the largest contribution to the AMV accident problem both collectively and individually. The following findings combine information from the statistical and accident report analyses for the *tactical* vehicles making the largest contributions to the AMV accident problem.

## ¼-ton trucks (Jeeps)

There were three significantly different aspects of FY 79 ¼-ton truck (Jeep) accidents:

• Drivers of ¼-ton trucks made significantly more errors of *operating or working at an unsafe speed* (24%) in their accidents than the average AMV (19%).

• Significantly more ¼-ton trucks *overturned* (25%) in their accidents than the average AMV (9%).

• Drivers of ¼-ton trucks made significantly more (15%) *failure to maintain control* errors than drivers of other *tactical* vehicles (11%).

The accident reports citing *unsafe speed, failure to maintain control,* and *overturned* were basically the same set of accidents. That is:

• Seventy-five percent of the *overturned* accidents also involved *unsafe speed* and/or *failure to maintain control.*

• Seventy-two percent of the *failure to maintain control* accidents also involved *unsafe speed* and/or *overturned.*

• Sixty-eight percent of the *unsafe speed* accidents also involved *failure to maintain control* and/or *overturned.*

The accident reports in these three problem areas were reviewed to identify cause factors. Not surprisingly, the factors involved in the *overturned* accidents were found to be the same as those in the *unsafe speed* and *failure to maintain control* accidents. Since the accidents and cause factors were basically the same, the analysis was focused on the *overturned* problem area.

Results of the analysis of the *overturned* problem area are presented below. It should be noted that the proportion of ¼-ton trucks found by this review of accident reports to be *overturned* (27%) differs from that (25%) reported in the statistical analysis. This difference is due to the fact that only one type of collision is recorded in the statistical data base when more than one type can occur.

Cause factors for the 242 *overturned* accidents are as follows:

• **Encountering hazardous road conditions.**

a. Fifty-eight (24%) of the cases involved this factor.

b. In the 58 cases, the vehicles involved were:

(1) M151A2, M825, M718A1—45 (78%)

(2) M151A1, M151A1C, M718—11 (19%)

(3) Unspecified M151—2 (3%)

c. There were 88 hazardous road conditions cited:

(1) Slippery (ice, snow, wet, gravel, mud, etc.)—38 (43%)

(2) Inclined (uphill or downhill)—27 (31%)

(3) Uneven (pot holes, bumps, ruts, washouts, etc.)—20 (23%)

(4) Soft (sand, soft road shoulder, etc.)—3 (3%)

d. Twenty-seven of the cases reported speed of the vehicle at time of the accident. The average speed was 20 mph.

• **Abrupt steering response.**

a. Fifty-six (23%) of the cases involved this factor.

b. In the 56 cases, the vehicles involved were:

(1) M151A2, M825, M718A1—31 (55%)

(2) M151A1, M151A1C, M718—21 (38%)

(3) Unspecified M151—4 (7%)

c. Twenty-three of the cases reported speed of the vehicle at time of the accident. The average speed was 31 mph.

d. Most of these cases involved

**TABLE 1.—FY 79 AMV Accidents**

| Type AMV | Accidents | Percent | Injuries | | Dollar Cost | | |
|---|---|---|---|---|---|---|---|
| | | | Fatal | Nonfatal | Injury | Property | Total |
| **Tactical** | | | | | | | |
| ¼-ton truck (Jeep) | 902 | 14 | 14 | 325 | $1,764,885 | $1,509,748 | $3,274,633 |
| M880 series truck | 637 | 10 | 2 | 58 | $648,905 | $1,386,620 | $2,035,525 |
| 2½-ton truck | 588 | 9 | 24 | 79 | $1,137,430 | $2,281,638 | $3,419,068 |
| 5-ton truck | 520 | 8 | 5 | 45 | $307,220 | $2,169,442 | $2,476,662 |
| Truck, unspecified | 429 | 7 | 4 | 65 | $337,220 | $718,727 | $1,055,947 |
| Gamma Goat | 137 | 2 | 9 | 46 | $386,525 | $533,101 | $919,626 |
| 8- and 10-ton trucks | 88 | 1 | 1 | 10 | $52,180 | $337,989 | $390,169 |
| Heavy equip transport | 19 | .3 | 0 | 0 | 0 | $169,354 | $169,354 |
| ½- to 1½-ton trucks | 14 | .2 | 0 | 1 | $280 | $13,534 | $13,814 |
| **Commercial/admin** | | | | | | | |
| Sedan/station wagon | 1,103 | 17 | 1 | 64 | $334,320 | $1,441,077 | $1,775,397 |
| Over 1-ton truck | 587 | 9 | 2 | 52 | $143,405 | $1,130,696 | $1,274,101 |
| Emergency vehicle | 390 | 6 | 1 | 50 | $221,790 | $647,806 | $869,596 |
| ¼- to ¾-ton trucks | 360 | 5 | 0 | 50 | $43,905 | $435,660 | $479,565 |
| Truck, unspecified | 314 | 5 | 3 | 45 | $229,190 | $397,733 | $626,923 |
| Bus | 248 | 4 | 0 | 15 | $22,550 | $340,416 | $362,966 |
| **Other** | | | | | | | |
| Other AMV | 264 | 4 | 2 | 42 | $132,000 | $650,030 | $782,030 |
| **Total** | 6,600 | 100 | 68 | 947 | $5,761,805 | $14,163,571 | $19,925,376 |

overcorrections (19) or abrupt steering in attempts to avoid other vehicles (16), animals (9), hazardous road conditions (7), or in the process of passing/overtaking other vehicles (4).

• **Negotiating a curve or turn with hazardous road conditions.**

a. Thirty-eight (16%) of the cases involved this factor.

b. In the 38 cases, the vehicles involved were:

(1) M151A2, M825, M718A1—20 (53%)

(2) M151A1, M151A1C, M718—17 (45%)

(3) Unspecified M151—1 (3%)

c. There were 50 hazardous road conditions cited:

(1) Slippery (ice, snow, wet, gravel, mud, etc.)—30 (60%)

(2) Uneven (pot holes, bumps, ruts, washouts, etc.)—11 (22%)

(3) Inclined (uphill or downhill)—9 (18%)

d. Twenty-three of the cases reported speed of the vehicle at time of the accident. The average speed was 25 mph.

• **Negotiating a curve or turn with excessive speed.**

a. Forty-three (18%) of the cases involved this factor.

b. In the 43 cases, the vehicles involved were:

(1) M151A2, M825, M718A1—25 (58%)

(2) M151A1, M151A1C, M718—15 (35%)

(3) Unspecified M151—3 (7%)

c. Twenty-two of the cases reported speed of the vehicle at time of the accident. The average speed was 35 mph.

• **Miscellaneous causes.**

a. Forty-seven (19%) of the cases involved miscellaneous causes.

b. In the 47 cases, the vehicles involved were:

(1) M151A2, M825, M718A1—34 (72%)

(2) M151A1, M151A1C, M718—12 (26%)

(3) Unspecified M151—1 (2%)

c. Ten of the cases reported speed of the vehicle at time of the accident. The average speed was 28 mph.

d. In 11 of these cases there was insufficient information to determine what caused the vehicle to *overturn*. The remaining 36 cases were divided between human error (18) and materiel failure (18) cause factors. There were three types of human error that occurred more than once: alcohol (3), inattention (2), and no ground guide (2). There were also three types of materiel failure that occurred more than once: brakes (7), tire blow out (5), and rear end locked (2).

## M880 series trucks

There were six significantly different aspects of FY 79 M880 series truck accidents:

• Drivers of M880 series trucks made significantly more errors of *operating or working at an unsafe speed* (22%) in their accidents than the average AMV (19%).

• Among the hazardous *surface conditions* that contributed to accidents, *snow/ice/sleet/frost* contributed to significantly more M880 accidents (33%) than the average AMV (27%).

• In accidents involving *collision with a fixed object (other than a vehicle)* there were significantly more M880 series trucks (21%) than the average AMV (17%).

• Drivers of M880 series trucks made significantly more (8%) *improper backing* errors than drivers of other *tactical* vehicles (5%).

• Of the M880 accidents involving *unsafe mechanical/physical conditions,* 17 percent were *mechanical defects.* Among these *mechanical defects,* there were significantly more defects involving *wheels/tires* (30%) and *steering mechanisms* (20%) than other *tactical* vehicles (9% and 6%).

Accident reports in the six problem areas were reviewed to identify cause factors. Accidents involving *operating or working at an unsafe speed* were due primarily (59%) to speed excessive for conditions, i.e., hazardous *surface conditions* (51%) and negotiating curves/turns (9%). It should be noted that 90 of the cases reported speed of the vehicle at time of the accident. The average speed was 33 mph.

Since most of the accidents involving *snow/ice/sleet/frost* (60%) and *collision with a fixed object (other than a vehicle)* (58%) were interrelated with those involving *operating or working at an unsafe speed,* they were not investigated further. However, results of the analysis of the *improper backing, wheels/tires,* and *steering mechanism* problem areas are presented below.

### *Improper backing*

• Sixty-five M880 series truck accidents involved *improper backing*.

• Of the 42 cases reporting mission, 74 percent were on administrative/garrison type missions while only 26 percent were on tactical/training missions.

• Of the 55 cases reporting accident situation, 35 percent involved backing in traffic conditions and 65 percent did not.

• Of the obstacles struck while backing, 60 percent were parked or standing vehicles, 15 percent were moving vehicles, 12 percent were vehicles whose motion status was not reported, 2 percent were individuals, and 11 percent were miscellaneous objects such as trees, stumps, etc.

• Forty-six percent of the *improper backing* accidents occurred on a road/street/highway, 8 percent occurred in the motor pool, 21 percent occurred in a parking lot, and 25 percent occurred in other locations or the location was not reported.

• Cause factors for the 65 *improper backing* accidents were as follows:

a. **No ground guide.** In 85 percent of the accidents, no ground guide was used to assist the driver in backing.

(1) In general, ground guides are not required for M880 series trucks. However, unit SOP can require the use of ground guides when backing these vehicles.

(2) Unit SOP required a ground guide in 42 percent of the no ground guide cases. No ground guide requirement was reported for 58 percent.

(3) In these 55 no ground guide accidents, no ground guide was available in 9 percent, a ground guide was available but not used in 20 percent, and ground guide availability was not reported in 71 percent.

b. **Inadequate coordination.** In 11

percent of the accidents, inadequate coordination between driver and ground guide contributed to the accident. In these accidents, the problems were:

(1) Poor/inadequate ground guiding—4

(2) Ground guide was positioned improperly—1

(3) Ground guide/driver communications breakdown—1

(4) Driver not watching guide—1

c. **Miscellaneous.** Five percent of the accidents involved miscellaneous causes. In these 3 cases, the causes were:

(1) Allowed vehicle to roll back—1

(2) Insufficient information—1

(3) Driver's hands slipped off steering wheel—1

### *Wheels/tires*

- Twenty-six M880 series truck accidents were caused by *wheel/tire* problems.
- There were 17 cases reporting speed at time of the accident. The average speed was 45 mph.
- The 26 accidents had *wheel or tire* problems involving the following:
  a. Left front tire—9 (35%)
  b. Right front tire—6 (23%)
  c. Left rear tire—3 (11%)
  d. Right rear tire—3 (11%)
  e. More than one tire—2 (8%)
  f. Problem tire location unreported—3 (11%)
- The *wheel or tire* problems involved were as follows:

a. **Tire blow out.** In 69 percent of the cases, a tire blew out. The following were causes of tire blow outs:

(1) Defective tires—5

(2) Uneven roads—3

(3) Overheated tires—1

(4) Tread separation—2

(5) Unknown—7

b. **Tread separation.** In 11 percent of the cases, tread separation (without blow out) was involved. The following were causes of tread separation:

(1) Defective tires—2

(2) Unknown—1

c. **Skidding/sliding.** In 11 percent of the cases skidding or sliding occurred due to wheel or tire problems. The causes of these skids and slides were as follows:

(1) Defective tires—1

(2) Loss of air pressure—1

(3) Tire broke traction, cause unreported—1

d. **Miscellaneous.** Miscellaneous wheel and tire problems were involved in 8 percent of the cases. These problems were as follows:

(1) Mismatched radials—1

(2) Wheel came off, cause unreported—1

- Defective tires were reported in 31 percent (8) of the 26 accidents involving wheel or tire problems. Thirty-seven percent (3) of these problems were attributed to faulty Goodyear radial tires.

### *Steering mechanisms*

- Five M880 series truck accidents were caused by steering problems.
- Two cases reported speed at the time of the accident. The average speed was 39 mph.
- Steering problems involved in the accidents were as follows:
  a. Vehicle pulled right—2
  b. Steering locked/no steering—2
  c. Steering difficult—1
- *Steering mechanisms* which caused the problems were as follows:
  a. Ice in worm gear housing—1
  b. Weak axle—1
  c. Unreported—3

## 2½-ton tactical trucks

There were three significantly different aspects of FY 79 2½-ton truck accidents:

- Significantly more 2½-ton trucks (34%) were involved in *collisions with a parked or standing vehicle* than the average AMV (28%).
- *Weather* factors contributed to 13 percent of the 2½-ton truck accidents. Among these, there were significantly more *extreme low temperature* factors (20%) than the average AMV (13%).
- Drivers of 2½-ton trucks made significantly more (9%) *improper backing* errors than drivers of other *tactical* vehicles (5%).
- Of the 2½-ton truck accidents, 176 (30%) involved *unsafe mechanical/physical conditions*. In these accidents, 191 conditions were identified, of which there were significantly more (47%) *mechanical defects* than the average AMV (25%). Of these *mechanical defects,* 74 percent involved *brakes* which was significantly greater than other *tactical* vehicles (59%).

The findings regarding *collisions with a parked or standing vehicle* were not investigated further due to the probable relationship with vehicle size, restricted driver visibility, and frequent use on administrative missions.

The 18 cases citing *extreme low temperature* were reviewed. In 13 (72%) of these cases, the cause factor was road surfaces made slippery by ice or snow which made temperature only an indirect factor. In 4 (22%) of these cases, low temperatures were present but were not a factor. In 1 (6%) of the cases, the driver received cold injuries because the vehicle was not equipped with a heater and the cab top had been removed due to unserviceability. The cases citing *extreme low temperature* were not investigated further.

Accident reports for the *improper backing* and *brake* problem areas were reviewed to identify cause factors. Results of the analysis of these problem areas are presented below.

### *Improper backing*

- Almost all (88%) of the 77 *improper backing* accidents involved the M35/M36 series truck.
- Of the 59 cases reporting mission, 80 percent were on administrative/garrison type missions while only 20 percent were on tactical/training missions.
- Of the 74 cases reporting the accident situation, 38 percent involved backing in traffic conditions and 62 percent did not.
- Of the obstacles struck while backing, 70 percent were parked or standing vehicles, 9 percent were moving vehicles, 5 percent were individuals, and 16 percent were miscellaneous objects such as trees, buildings, stumps, etc.
- Cause factors for the 77 *improper backing* accidents are as follows:

a. **No ground guide.** In 61 percent of the accidents, no ground guide was used to assist the driver in backing. In these 47 accidents, no ground guide was available in 34 percent, a ground guide was available but not used in 23 percent, and ground guide availability was not reported in 43 percent.

b. **Inadequate coordination.** In 21 percent of the accidents, inadequate coordination between driver and ground guide contributed to the accident. In these 16 accidents, the problems were:

(1) Ground guide gave verbal signal only—5

(2) Ground guide was out of position—3

(3) Ground guide failed to see obstacle—3

(4) Driver did not stop when guide not in sight—2

(5) Guide failed to signal—1

(6) Driver not watching guide—1

(7) Driver misunderstood guide signal—1

c. **Miscellaneous.** Fourteen (18%) of the accidents involved miscellaneous causes. These causes were:

(1) Driver's foot slipped off brake or clutch—3

(2) Driver mistakenly put vehicle in reverse—3

(3) Braked but vehicle slid on packed snow—1

(4) Allowed vehicle to roll back—1

(5) Unlicensed driver—1

(6) Insufficient information—5

### *Brakes*

- Almost all (90%) of the 70 accidents caused by brake failure involved the M35/M36 series truck.
- There were 29 cases reporting speed at time of the accident. The average speed was 18 mph.
- When brake failure occurred, 93 percent of the vehicles were underway and 7 percent were parked.
- The following factors were reported as contributing to some of the 70 accidents.

a. Inadequate before-operations check—17%

b. Emergency brake failed after service brake failure—13%

c. Vehicle was operated with known brake problem—10%

- The brake system components which failed are as follows:

a. Brake line—21%

b. Hydravac—14%

c. Wheel cylinder—9%

d. Master cylinder—6%

e. Emergency brake (while parked)—6%

f. Brake shoes—1%

g. Unspecified component—43%

## 5-ton tactical trucks

There were three significantly different aspects of FY 79 5-ton truck accidents:

- 5-ton trucks were placed, by their drivers, in an *unsafe position or posture* significantly more (120/15%) than the average AMV (12%).
- Significantly more (173/33%) 5-ton trucks were involved in *collision with a parked or standing vehicle* than the average AMV (28%).
- *Unsafe mechanical/physical conditions* were involved in 183 (35%) of the 5-ton truck accidents. In these accidents, 202 conditions were identified, of which there were significantly more (40%) *mechanical defects* than the average AMV (25%). Of these *mechanical defects*, 75 percent involved *brakes* which was significantly greater than other *tactical* vehicles (59%).

Accident reports in the three problem areas were reviewed to identify cause factors. Those involving *unsafe position or posture* were due primarily (68%) to *following too closely*. Those involving *collision with a parked or standing vehicle* were due primarily to *following too closely* (30%), *improper turning* (15%), *improper backing* (11%), and *unsafe speed* (11%). These problem areas were not investigated further due to their probable relationship with vehicle size, restricted driver visibility, and administrative missions. Results of the analysis of the *brake* problem area are presented below.

### *Brakes*

- The 58 accidents caused by brake failure involved the following configurations of the 5-ton truck.

a. 6x6 dump—26%

b. 6x6 cargo—21%

c. 6x6 wrecker—14%

d. 6x6 tractor—36%

e. 8x8 cargo—3%

- There were 19 cases reporting speed at time of the accident. The average speed was 19 mph.
- When brake failure occurred, 88 percent of the vehicles were underway and 12 percent were parked.
- The brake system components which failed are as follows:

a. Brake line—14%

b. Emergency brake (while parked)—12%

c. Hydravac—7%

d. Wheel cylinder—7%

e. Master cylinder—7%

f. Miscellaneous—5%

g. Unspecified component—48%

## M561/M792 Gamma Goats

There were two significantly different aspects of FY 79 Gamma Goat accidents:

- Forty-seven (34%) of the Gamma Goat accidents involved *unsafe mechanical/physical conditions.* In these accidents, 53 conditions were identified, of which there were significantly more (42%) *mechanical defects* than the average AMV (25%).
- Significantly more Gamma Goats *overturned* (18%) in their accidents than the average AMV (9%).
- The *mechanical defects* involved brakes (9), wheels/tires (4), steering (3), frame/body (2), safety devices (2), and ignition (1). Proportionately, however, none of these *mechanical defects* was significantly larger than for other *tactical* vehicles. For example, brakes were 43 percent of the Gamma Goat *mechanical defects* versus 59 percent for all *tactical* vehicles. Therefore, Gamma Goat *mechanical defects* were not investigated further.

Accident reports for the *overturned* problem area were reviewed to identify cause factors. Results of the analysis of this problem area are presented below.

### *Overturned*

Cause factors for the 24 *overturned*

accidents are as follows:

- **Encountering hazardous road conditions.**

a. Four (17%) of the cases involved this factor.

b. There were 4 hazardous road conditions cited:

(1) Inclined (uphill or downhill)—3 (75%)

(2) Slippery (ice, snow, wet, gravel, mud, etc.)—1 (25%)

c. Three of the cases reported speed of the vehicle at time of the accident. The average speed was 22 mph.

- **Abrupt steering response.**

a. Ten (42%) of the cases involved this factor.

b. Five of the cases reported speed of the vehicle at time of the accident. The average speed was 29 mph.

c. These cases involved overcorrections (8), oversteering a curve (1), and abrupt steering to avoid another vehicle (1).

- **Negotiating a curve or turn with hazardous road conditions.**

a. Only one case (4%) involved this factor.

b. The hazardous road conditions cited were slippery (loose shale) and inclined (downhill).

- **Negotiating a curve or turn with excessive speed.**

a. Four (17%) of the cases involved this factor.

b. Two of the cases reported speed of the vehicle at time of the accident. The average speed was 33 mph.

- **Mechanical defect/failure.**

a. Only one case (4%) involved this factor.

b. The mechanical defect was a steering failure.

c. The speed of the vehicle was less than 5 mph.

- **Miscellaneous causes.**

a. Four (17%) of the cases involved this factor.

b. Two vehicles reported speed of vehicle at time of the accident. The average speed was 20 mph.

c. In one case there was insufficient information to determine what caused the vehicle to *overturn.* The remaining three cases were caused by human error: alcohol, improper vehicle towing, and failure to negotiate a curve due to inexperience.

## 8- and 10-ton tactical trucks

There were two significantly different aspects of FY 79 8- and 10-ton truck accidents:

- Forty percent of the 8- and 10-ton accidents involved *unsafe mechanical/physical conditions.* In these accidents, 39 conditions were identified, of which there were significantly more (38%) instances of *hazardous arrangement/procedure* than the average AMV (17%).
- Drivers of 8- and 10-ton trucks made significantly more (17%) *improper turning* errors than drivers of other *tactical* vehicles (5%).

The cases involving *hazardous arrangement/procedure* were investigated by further statistical analysis and review of a sample (40%) of the accident reports. This investigation indicated that the *hazardous arrangement/procedures* related primarily to the operation of these large tractor-trailer rigs in restricted/congested traffic situations. This problem area was not investigated further since it was found to be highly related to the *improper turning* problem area. Accident reports for the *improper turning* problem area were reviewed to identify cause factors. Results of the analysis of this problem area are presented below.

### *Improper turning*

- The 18 accidents caused by *improper turning* involved:

a. 10-ton tractor trailers—78%

b. 8-ton GOERs (M520, M559)—22%

- The direction of turn was 39 percent left, 22 percent right, and 39 percent not reported.
- Most (75%) of the accidents occurred while the driver was turning at an intersection.
- In 16 (89%) of the cases the trucks were pulling a trailer (78%) or another vehicle (11%). In these 16 cases, the trailer or towed vehicle produced the damage 94 percent of the time.
- In almost all (89%) of the cases the object hit by the 8- and 10-ton trucks was a vehicle: 83 percent were parked or stationary and 6 percent were moving.

## Discussion and Conclusions

In FY 79, AMV was the most frequent type of Army accident. Among AMV accidents, those involving *tactical* vehicles were the biggest problem in terms of total and average cost. For example, although sedans/station wagons in the *commercial/administrative* group were the most frequent type of AMV accident, they ranked fifth in total cost (behind four *tactical* vehicles) and fourteenth in average cost. Most accidents in this group could be characterized as "minor damage, minor injury, fender benders."

On the other hand, the top seven types of AMV accidents in terms of average cost involved *tactical* vehicles. Property damage accounted for more than 50 percent of the cost in all these vehicles with the exception of ¼-ton trucks (Jeeps) where injuries accounted for 54 percent of the cost.

Two types of vehicles were real injury producers: 40 percent of the Gamma Goat accidents and 38 percent of the ¼-ton truck (Jeep) accidents resulted in injury versus 15 percent for all AMV accidents. This is related to the finding that significantly more of the ¼-ton trucks (25%) and Gamma Goats (18%) *overturned* in their accidents than other AMVs (9%). The factors involved in these *overturned* accidents were similar for both vehicles: abrupt steering, hazardous road conditions, and negotiating curves/turns. The problem appears to be one of "design versus use." That is, the vehicles are designed for off the road *tactical* operations but frequently are used on the road and are expected to drive like commercial vehicles. For example, the steering ratio for ¼-ton trucks (16.4:1) turns what would be a normal steering response in a commercial vehicle (24:1 ratio) into an abrupt steering response in these *tactical* vehicles.

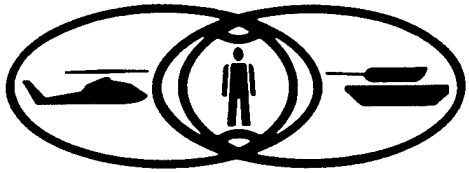
Also, centrifugal forces that result from negotiating curves have an abnormal impact on vehicles with a high center of gravity such as the ¼-ton truck. Consequently, drivers of these *tactical* vehicles who make steering responses, encounter

road hazards, and negotiate curves as though they were driving commercial type vehicles are in very real danger of *overturning* their vehicle. These steering and center of gravity problems have been known for some time, and the A2 model of the M151 was designed to reduce these problems. This redesign has helped significantly, as evidenced by the fact that in FY 79, the A2 model had 79 percent of the M151 exposure mileage but only 69 percent of the M151 *overturn* accidents. Also, training and warnings in the operator's manual have made the hazard known to M151 drivers. Since the problem will probably persist as long as the M151 is also used as an "on-the-road" vehicle, provisions for rollover protection and occupant restraint systems (at least for non-*tactical* missions) should be pursued.

As expected, driver error was the largest (71%) cause factor. Errors were generally related to the type vehicle, e.g., excessive speed in emergency vehicles and maneuvering/turning mistakes with 8- and 10-ton trucks and buses. However, drivers of 2½-ton trucks and M880 series trucks made significantly more (9% and 8%) errors of *improper backing* than drivers of other *tactical* vehicles (5%). In more than 70 percent of these cases, there was no ground guide and in 15 percent there was inadequate coordination between ground guide and driver. More than 75 percent of these accidents occurred during administrative/garrison type missions and involved backing into parked/standing vehicles in approximately 65 percent of the cases. The conclusion is that if these *tactical* vehicles are to be used for administrative/garrison type missions, then trained ground guides must be provided.

Environmental factors (*surface condition*—36%, *weather*—19%) were the second largest contributors to AMV accidents. Among *tactical* vehicles, M880 series trucks were significantly affected by *snow/ice/sleet/frost* and 2½-ton trucks were significantly affected by *extreme low temperatures.* These factors are related to the cause of the accidents in that they produced hazardous road conditions.

Mechanical/physical factors (28%) were the third largest contributors to AMV accidents. Among these, *mechanical defects* were most important and more than half of the *tactical* vehicle *mechanical defects* involved brakes. Brakes were a significant *mechanical defect* problem for two particular *tactical* vehicles: 2½-ton trucks (74%) and 5-ton trucks (75%). In almost half of the cases, the failed brake component was not specified. In those cases where it was specified, most of the failed components were brake line, hydravac, emergency brake (while parked), wheel cylinder, and master cylinder. The causes of these failures were rarely reported. Tire failure (30%) and steering malfunctions (20%) were significant *mechanical defect* problems for the M880 series truck. Most of the tire failures involved blow outs (69%) and tread separations without blow out (11%). In 31 percent of the cases the cause was cited as "defective" tires. Only two of the steering malfunction cases reported the cause: ice in worm gear housing (1) and weak axle (1).



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